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AUTHOR Baker, Dale; Jacobs, Kathy
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ABSTRACT

This paper discusses the success of single sex science and mathematics education classrooms. Most studies on single sex learning environments come from countries such as Australia, Jamaica, Nigeria, Great Britain, New Zealand, and Thailand, and there is little research on American public schools. This study investigates single sex mathematics and science education among male and female middle school students. Collected data was grouped into three categories: (1) achievement, opportunity to learn, curriculum, cognitive demands, pedagogy, and technology; (2) attitude, empowerment, self-concept, and peer interactions; and (3) discipline and teacher-student interactions. Results indicate that single sex classrooms primarily affect the achievement of girls much more than boys but in general, neither can be considered winners. (Contains 15 references.) (YDS)

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Winners and Losers in Single-sex Science and Mathematics Classrooms

Dale Baker and Kathy Jacobs

Curriculum and Instruction

Arizona State University

Tempe, AZ 85287-1911

602-965-6067

dale.baker@asu.edu

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D. Baker

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Theoretical Underpinnings of the Study

There has been a great deal of discussion about establishing single-sex classrooms for science and mathematics in pre-college education. This discussion has been prompted by research that indicates that classroom interactions, pedagogy and curriculum disadvantages females (Sadker & Sadker, 1994) especially in science and mathematics classrooms (Baker, 1998; Baker, 1987). The research also indicates that the cumulative effect of gender biased classrooms is negative attitudes toward science and mathematics, avoidance of science and mathematics courses, lower career aspirations and poor self-concepts (Baker & Piburn, 1997).

Because of the legal constraints of Title IX, the private sector took the first steps to create programs, targeted at girls only, to develop positive attitudes and self-concepts and to expose

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girls to female role models (Benore-Parsons, Fisher & Heady, 1995; Marshall & Buckingham, 1995). For example, the Fort Worth Museum of Science and History has been very successful in creating a single-sex, girl friendly environment to explore science. Graduates of this program like science, see themselves as competent learners of science and are planning science careers (Baker, Lindsey & Blair, 1999).

Public schools, wishing to duplicate these successes, have initiated pilot programs in which science and mathematics are taught separately to boys and girls. However, the most recent report of the American Association of University Women, (1998) challenges the idea that single-sex classrooms are good for girls. For example, Lee, Marks and Knowles (1991) found that many classes in independent all girl schools lacked academic rigor. Brown and Wood (1997) found that single-sex ninth grade mathematics classes, in a public high school, did not have an effect on grades, SAT scores or future course taking behavior. And, LePore and Warren (1997) found that single-sex secondary Catholic schools are not necessarily more favorable academic settings. Higher academic achievement was actually due to pre-enrollment differences.

Most studies of single-sex learning environments come from Australia, Jamaica, Nigeria, Great Britain, New Zealand and Thailand. These studies have mixed conclusions as to the benefits of single-sex education. In Australia, (Marsh & Rowe, 1996) found that achievement differences were attributable to characteristics of the students rather than the single-sex classroom. Parker and Rennieís (1995) and Rennie and Parkerís (in press) research is more encouraging. They found that single-sex classrooms provided supportive learning environments for girls but less supportive learning environments for boys and that single-sex classrooms had a positive effect on both attitude and achievement for boys and girls. Mael (1998), in a review of studies on single-sex learning environments world-wide, found that single-sex schools had more benefits for girls than boys.

However, because of the problems of generalizing from studies abroad and the low number of studies in American public schools, we should be cautious about advocating single-sex science and mathematics classes. Many factors remained to be explored such as grade level, ethnicity, SES, the curriculum, the duration and extent of the experience and finally how we define "good for girls" before authoritative recommendations can be made.

Purpose of the Study

This study was designed to investigating what occurred during a single school year in single-sex science and mathematics classrooms from the perspective of a university researcher, male and female middle school students, university interns and teachers. The study was conducted at the request of the teachers who had initiated single-sex classrooms, in the two years before the study, to help minority girls become more interested in science and mathematics.

Sample

The majority of the students were Hispanic followed by a smaller number of African American students. There were few Anglo students (1-2 per class). Many of the Hispanic students were not native speakers of English and several students in each class spoke no English. The students translated for one another and the teachers spoke rudimentary Spanish. Some of the students, mostly male, were gang members. The school was located in a poor, inner city school district with a highly transient population. In addition, the school had a large absentee rate.

There were approximately 100 students officially enrolled in the classes observed, but true numbers were difficult to obtain because of transience and absenteeism. The actual number of

students observed on each visit was much lower due to the high rate absenteeism. Because the population was very transient, the make-up of the classes was constantly changing throughout the year.

Some special education boys (2-3 per class) were placed in the all girl classes because they were unable to function in the all boy classes. The teachers also had more time to give to the special education boys in the all girl classes.

Procedures

The research was conducted in two single-sex 7th grade mathematics and two single-sex 7th grade science classrooms taught by female teachers. Three kinds of data were collected. The first was based on classroom observations made by a university researcher and a journal kept by a university intern who was in the classroom for the entire school year.

The second set of data came from teacher awarded grades and curriculum materials. Samples of worksheets, lab instructions and assessments were collected to determine the nature of the tasks that were used for grading.

The third set of data came from interviews of students (n=30), university interns (n=3) and teachers. Thirty students constituted approximately one third of the total student population. More girls than boys were interviewed because boys did not return permission slips from parents. Students were asked to compared their attitude toward the content and their self-concept now and when they were in mixed-sex classrooms. Overall, feelings about being in single-sex classrooms were also explored.

Teachers were asked to describe their feelings about teaching in single-sex classrooms, and how their feelings and the gender of the students influenced disciplinary, curricular and pedagogical decisions. The categories of data that emerged from all the sources were grouped into a cluster of 1) achievement, opportunity to learn, curriculum, cognitive demands, pedagogy, technology, 2) attitude, empowerment, self-concept, peer interactions, and 3) discipline, teacher-student interactions.

University interns were asked to confirm or deny hypotheses generated by the university researcher and to make observations according to the categories emerging from the university researcher's field note clusters as well as any other observations not included in the clusters.

Observations were made from the beginning of August to the end of March. Science classes were observed 20 times and mathematics classes 18 times. Each class observation lasted 110 minutes. Interviews of the teachers, university interns and students were conducted in April and May.

Results

The teachers created the single sex classrooms based on six assumptions. These were that single-sex classrooms would lead to higher academic achievement, better self-concepts, a feeling of empowerment, and better attitudes towards science and mathematics for girls. The teachers also assumed that girls would have more opportunities to be leaders and more opportunities to participate and speak out. The teachers did not give much thought to the effect single-sex classrooms would have on boys nor did they anticipate that it would change their life in the classroom as much as it did. The single-sex classrooms were put in place after a month's discussion between the mathematics and science teacher in one of the houses in the middle school. Single-sex classrooms were the science teacher's idea. Neither teachers did any reading of research or consulting with university faculty or other teachers who had tried single-sex classrooms. Parents were not consulted about whether their child would be in a single -sex or coed science or mathematics classroom.

The single-sex arrangement lasted three years. In the first year, there was an all boy day followed by an all girl day. The second and third year there were alternating periods of girls and boys in the same day. The switch from single-sex days to alternating periods came about because an all boy day was too difficult and exhausting. The teachers spoke of dressing for combat on all boy days. At the end of the third year, the science teacher announced that she could no longer tolerate the arrangement and would not teach single-sex classes in 1998-99.

Cluster 1: Achievement, Opportunity To Learn, Curriculum, Cognitive Demands, Pedagogy, Technology

Single-sex classrooms had an effect on achievement primarily for girls. Although all students earned higher grades in mathematics than science, boys did less well in both mathematics and science than girls. A large number of boys were failing while girls' grades were in the C to B range. This occurred because the mathematics activities were more to the boys' liking and required less independent thinking than the science activities. Grades were based entirely on a few tests and daily in class assignments. Boys did not complete or tun in tests and daily assignments. Both the science and mathematics teachers provided opportunities to make up missed assignments and to retake tests until a passing grade was achieved. The boys did more of the makeup tasks in mathematics than science but most boys did not do enough to achieve a passing grade. In addition, the girls helped one another to understand and complete the in-class group work while the boys did not help one another and sometimes actively interfered with each others' learning.

The poor grades of the boys can not necessarily be attributed to the single-sex environment, the curriculum in science and math, or the grading policies of the two teachers. Boys were also failing in greater numbers than girls in their coed classes such as language arts, fine arts, and social studies.

Girls sometimes had more opportunity to learn. What the teachers' planned for the day was covered in girls' classes but was not covered in boys' classes. Girls were also asked more higher level questions than boys. Girls said they were more willing to participate in the single-sex classroom and were less embarrassed without boys. On the other hand, girls had less opportunity to learn because girls were given free time when they had finished a task, so that boys and girls moved on to the next topic together.

Boys lost most of their opportunity to learn because they could not stay on task or work in groups well. Much instructional time was lost because of disciplinary interruptions.

The curriculum was undifferentiated. The same topics and activities were taught to boys and girls despite the fact that some topics and activities worked better with one sex than the other. In general, the curriculum was better suited to the interests of girls than the boys. Boys had difficulty in science doing group experiments and using materials appropriately. They also had difficulty doing long term mathematics activities e.g. planning and drawing a model town which required problem solving, decision making, calculations, group work and drawing to scale. Modifications to the curriculum were not made because of equity concerns.

The science curriculum was weighted heavily toward activities that had low structure and a high cognitive demand. Mathematics contained more high structure low cognitive demand tasks. Boys had more difficulty with both low structure and high cognitive demand tasks and high structure and low cognitive demand tasks than girls. Tasks that put high cognitive demands on boys did not always put high cognitive demands on girls. Again, despite the difficulties that teachers had in keeping boys on task, especially with low structure and high cognitive demand tasks, the cognitive demands of tasks were not modified.

Nor did the teachers use different pedagogies with boys and girls. Group work, working with a partner, and hands-on activities predominated. Lectures and note taking were more common in science than math. Math classes included doing problems by oneself. Both classes participated in writing across the curriculum and both teachers lead discussions.

Girls worked in groups or with a partner on hands-on activities better than boys except if the task took place outside and involved the expenditure of a great deal of energy e.g. math Olympics, or the use of CBLs. Girls participated in whole class discussions more easily than boys but were influenced by topic and mood. Neither girls nor boys could work in groups if they had to discuss and neither girls nor boys could do writing tasks easily. Competition and listening to lectures did not work for boys or girls either. Overall, labs, group roles, taking the perspective of another, materials use, clean-up, interpreting data, free time or choice were more difficult for boys than girls. In mathematics, in particular, boys preferred to do repetitive problems working alone or science activities involving live animals.

Teachers rarely changed pedagogy for students except as punishments for boys. Hands-on activities were replaced by writing and reading tasks.

Technology (CBLs, writing with a computer, websites and other internet activities) motivated boys to stay on task and cooperate-operate. Boys could think of extensions of activities if technology was involved. In fact, the only aspect of the curriculum that truly engaged the boys was the use of technology. When the boys were exploring internet sites or using hand held graphing calculators with probes they were on task, worked cooperatively in their groups, finished their tasks and created extensions of the activities on their own.

The girls were bored with these technologies. Technology based activities did not motivate girls and lead to off task behavior. Girls often would not look at the large computer monitor and did not find the mathematics and science internet sites interesting. When using hand held graphing calculators, they completed their tasks at the minimally acceptable level and did not play with the calculators to see what else they could do with the probes. E-mail generated some interest for girls as an after class activity because it promoted social interaction with friends and another way to write notes to each other.

Cluster 2: Attitude, Empowerment, Self-Concept, Peer Interactions

Students' attitudes toward mathematics and science were influenced by the teacher or task rather than the single-sex class arrangement. If they liked the teacher, they liked the subject. Boys had more negative attitudes toward all kinds of tasks than girls. Girls had negative attitudes toward writing tasks but loved labs and hands-on tasks. Girls were more compliant even if they held negative attitudes about tasks. One of the ways students expressed negative attitudes was whether or not they came to class prepared to work. Girls came prepared for class more often (supplies, agendas, homework) than boys.

Girls preferred the all girl classes because girls were supportive of each other, everyone could contribute to a task and there were opportunities to be both a leader and follower. Girls reported losing some of the feeling of leadership when boys were present. Girls described boys as noisy, distracting and mean. Occasionally a girl would prefer a mixed class because she wanted to flirt with boys or because being with boys made her feel academically superior.

The boys felt that they did not help, support or respect one another. Consequently, many boys prefer mixed classes. The all boy classes made it difficult to learn whereas girls would help a boy if he asked. However, boys did not feel that their ideas were respected in either single-sex or coed classrooms. Perhaps this was because the girls felt superior intellectually and academically to the boys. Overall, the boys felt that the presence of girls created a better learning environment. However, because the boys liked to be with their friends about half also preferred the all boy classes for social reasons.

The girls' self-concept was better than the boys' self-concept. Girls felt smart, like they had a lot to contribute, like they were learning, and like scientists. The presence of boys in other classes made girls feel even smarter because they helped the boys and understood the tasks better than boys. On he other hand, girls felt like they were learning less when boys were present.

Boys were not sure they were smart. They did not feel they had much to contribute and did not feel like they were learning a lot. Nor, did they feel like scientists in single-sex classrooms. The presence of girls made boys feel smarter and like they were learning because the environment was quieter and less chaotic and the girls helped the boys, enabling them to finish tasks.

The single-sex classes were not empowering for either girls or boys because both teachers' instructional styles made it very clear that they were in charge.

Cluster 3: Discipline, Teacher-Student Interactions

The all boy classrooms were noisier and more hostile environments and discipline was a problem. Gang and inter-ethnic confrontations were common. Boys hit, punched and tripped each other both in anger and for fun. Verbal interactions consisted of swearing, threats of bodily harm and ridicule. Small or studious or white boys were often victims of physical and verbal attacks. Boys had a greater need for physical movement and to verbalize than girls which teachers interpreted as a disciplinary problem. Despite the teachers perceptions, boys were often working when tapping pencils, humming, and bouncing in their seats. Less was accomplished in boys' classes due to disciplinary problems.

Physical and verbal attacks did not occur in the all girl classes. Nor was there inter-ethnic strife. This does not mean that the girls were always on task but the teachers did not perceive girls as discipline problems because they were quiet (daydreaming, writing notes, putting on make-up and nail polish). Teachers showed favoritism and tolerated more disciplinary infractions from girls than boys because the infractions were not as obvious. Consequently, teachers disciplined boys more than girls.

Teachers preferred teaching the girls and dreaded teaching certain classes of boys. This preference was communicated in many ways. They were harsh with boys (tone of voice, body language, use of classroom space) and soft with girls. The teachers showed more favoritism towards girls than boys and sometimes even told the girls that they were the favorites. The teachers also had more social interactions and shared more of their personal lives with girls than boys. The science teacher become physically ill with asthma attacks when teaching boys and the math teacher reported that nervous with boys. Observations confirmed her nervousness.

Conclusions

There were no winners in this study. Girls and boys both lost because the teachers did not make the kinds of curricular and pedagogical changes that would have best suited them. The boys need tasks that reflected their interests, more structure, tasks broken into smaller pieces, and more technology to excel. Girls needed to be allowed to move ahead when they were ready and tasks that reflected their interests. The failure of boys in the coed classes raises the question of whether anything the school was doing was meeting the needs of the boys.

Boys lost in a particularly unfortunate way because they were viewed as a problem by both the teachers , girls and boys themselves. Girls were viewed as the "good students" by teachers, boys and themselves. From an outsiders perspective, the behavior of the girls was not so different from the boys that such as disparity in perceptions was warranted.

Girls lost in a particularly unfortunate way because they are now back in coed classrooms where they will have fewer opportunities to be a leader, to participate and speak out and to

learn in a harassment free environment. Girls will be used to dilute the effect of the boys, to keep the boys calm and to make the teacher's job easier. Boys won because their opportunities to learn will be increased by the presence of girls who will help them and contribute to a calmer learning environment.

The teachers were also losers because they did not understand that equity is often better promoted by doing things differently to meet different student needs. They jumped into the single sex-classrooms without any advanced preparation and they terminated the experiment abruptly without a discussion of how the situation could be improved.

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